"EFFICACY OF FUNCTIONAL RESISTANCE EXERCISE ON AMBULATION SKILLS OF SPASTIC DIPLEGIC CEREBRAL PALSY"

Dissertation submitted in

Partial fulfillment for the Degree of

MASTER OF PHYSIOTHERAPY

(ADVANCED PHYSIOTHERAPY IN PEDIATRICS)

THE TAMIL NADU DR. M. G. R. MEDICAL UNIVERSITY ,CHENNAI

LINSHINA T.

REG NO: 271340042

COLLEGE OF PHYSIOTHERAPY,
CHERRAAN'S INSTITUTE OF HEALTH SCIENCES, COIMBATORE

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CERTIFICATE

The work embodied in the thesis entitled **"EFFICACY OF FUNCTIONAL RESISTANCE EXERCISE ON AMBULATION SKILLS OF SPASTIC DIPLEGICS CEREBRAL PALSY"** submitted to the **'The Tamil Nadu Dr. M.G.R. Medical University, Chennai'** in partial fulfillment for the degree of **Master of Physiotherapy (Advanced PT in Pediatrics)** was carried out by candidate bearing Register number 271340042, **College of Physiotherapy, Cherraan's Institute of Health Sciences, Coimbatore** under my supervision. This is an original work done by her and has not been submitted in part or full for any other degree / diploma at this or any other university / institute. The thesis is fit to be considered for evaluation for award of the Degree of Master of Physiotherapy.

Signature of the Supervisor **Signature of the Principal**

Internal examiner **External examiner**

Dissertation evaluated on:

COLLEGE OF PHYSIOTHERAPY,

CHERRAAN'S INSTITUTE OF HEALTH SCIENCES, COIMBATORE

DECLARATON

The work embodied in the thesis entitled **"EFFICACY OF FUNCTIONAL RESISTANCE EXERCISE ON AMBULATION SKILLS OF SPASTIC DIPLEGICS CEREBRAL PALSY"** submitted to the **'The Tamil Nadu Dr. M.G.R. Medical University, Chennai'** in partial fulfillment for the degree of **Master of Physiotherapy (Advanced PT in Pediatrics)** was the original work carried out by me and has not has not been submitted in part or full for any other degree / diploma at this or any other university / institute. All the ideas and references are been duly acknowledged.

Signature of the Supervisor **Signature of the Student**

Date:

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CONTENTS

ABSTRACT

"EFFICACY OF FUNCTIONAL RESISTANCE EXERCISE ON AMBULATION SKILLS OF SPASTIC DIPLEGICS CEREBRAL PALSY"

Linshina T, College of Physiotherapy, Cherraan's Institute of Health Sciences, Coimbatore

Background: Functional Resistance Training is slowing gaining recognition among the Physiotherapist dealing with Cerebral Palsy. However the practical application of this compound strength training has not studied yet in developing the ambulatory skills of Spastic Diplegics. **Objectives:** To study the effectiveness of 'functional resistance training' and compare it with conventional 'symptom based treatment approach' in improving gait parameters of spastic diplegics aged between 6 - 14 years. **Materials and Methods:** Single blinded experimental, comparative study done at DEIC, Malappuram. 30 numbers of Conveniently chosen Spastic Diplegics aged below 14 years were randomly divided into 2 groups. Group A & B (Experimental and Conventional respectively) were intervened for 90 Minutes of therapy regularly for 4 months. GMFM 66, Stride length, Step length and Cadence were considered as the outcome measures. Pre and Post intervention values were tabulated and treated statistically using 't tests'. **Results:** Both the groups shown improvement after intervention. Inter-group comparison done using 'independent t test' reveals statistically significant progress in experimental group (GMFM (P=0.001), Stride length (P=<0.001) and step length (P=<0.001), and cadence compared to Group B**. Conclusion:** The results of this study indicate that functional resistance training is better than conventional symptoms based treatment approach to develop ambulatory skills of spastic diplegic cerebral palsy.

Key words: Cerebral Palsy, Spastic diplegic, Functional Resistance Training, Symptoms Based Treatment, GMFM

Introduction

Chapter 1

INTRODUCTION

'Cerebral Palsy (CP)', with reference to the “National Center on Birth Defects and Developmental Disabilities”, “Dorlands Medical Dictionary” and the published work of Beukelman, David R, Mirenda, Pat, the Wikipedia defines it as an “broad term for a group of non-progressive motor conditions that leads to disability in various phases of human movements. [1-4] Cerebral palsy occurs approximately 2.5 in every 1000 births. [5]

According to the ICF **- Disability and Health of** WHO - *Geneva*, the clinical manifestations of CP children limits them to perform their activities of daily living and confines them in playing their role in the society as an individual. [6] NSSO’s 2002 census data 57.50 percent of disabled were suffering from gait (locomotor) gait disability. [7]

According to ICF definitions the term 'Impairments' are any deviations structure or functions. The term 'Limitations' are the difficulties in functioning. 'Participation restrictions' are the exertion while involving in the daily living activities. The aims of ICF is to promote functional mobility and participation in daily activities related to the individual and social life of the children with Cerebral Palsy. [8]

Children with cerebral palsy usually presents with disturbance in muscle tone (largely hypertonic or spasticity), lesser muscle strength, pain & selective motor control. These impairments limits the performance including locomotion thereby

participation in daily life. In this scenario, promoting, optimizing daily deeds and participation are the three major goals of rehabilitation medicine. [9]

Velocity dependent hypertonicity or Spasticity (a classical sign of UMN lesion), is the most common problem in children with Cerebral Palsy. Physiotherapisits believed that it is not weakness but spasticity is the major problem that limits functional skills in children with Cerebral Palsy. [10] Until recent years, the therapeutic approach were aiming at reducing the spasticity and not to promote any kind of resistive training on the anti-gravity muscles. The myth was resistive training increases spasticity and its complications, as followed in Bobath's approach in the management of cerebral palsy. [11]

Spastic diplegia refers to motor limitations and incoordination involving the lower limbs. The upper limbs are seldom affected in this condition. Crouching is the most common gait type seen in spastic diplegia which involves flexion of hip, knee and dorsi flexion of ankle. This implicate weakness of the ankle plantar flexors, knee extensors and hip extensors. Children with crouch gait typically walk slowly and have great difficulty in ascending and descending. [12]

As a part of the rehabilitation team, the role of a Physiotherapist is to develop therapeutic protocols to optimize the sensory motor liabilities in children with CP and facilitate participation in self-care and daily living activities. [4] The primary therapeutic goal set for a spastic diplegia by a therapist is to improve his/her ability to ambulate. [8]

The trends of physiotherapy are to identify and train the underperforming muscles of a cerebral palsy client. Most of the therapists apply progressive resistance in the form of manual resistance, free weights, therapeutic gym, elastic bands etc. These exercises are collectively considered as conventional physio-therapeutics. Functional resistance exercises" or "Task Oriented Approach" is a broad term used for re-education of a major function, eg: Gait. by application of isometric or isotonic resistance, throughout the range of movement in an activity similar to the activity you are trying to regain. [13 - 16] Originally, functional approach were utilized only in the later stages of rehabilitation of stroke, head Injury clients etc.

The newer ideas of rehabilitation favour functional learning; i.e., "the one who wants to learn walking has to walk." [17] Additional benefits of strengthening of hip, knee and ankle extensors may be achieved without isolated joint exercises. [18] Use of gait trainers like treadmill, simulated community walking etc may improve walking in children with CP because it provides an opportunity to repetitively train the whole gait cycle. [9]

Motor skills in children with cerebral palsy can be classified and can be tested using Gross Motor Function Measure (GMFM). The "Gross Motor Functional Classification System" (GMFCS) is a clinical scaling based on walking and sitting abilities of the child. Children at level I & II are independent walkers where are children at level III and above requires mechannical or manual assistance. [19, 20]

The GMFM is a test in five dimensions including lying, sitting, crawling, standing, and walking. [21] GMFM 66 is the second version of GMFM scaling. This

proved to be superior to the earlier versions. [22] It is stated that muscle weakness is the major reason for variance in the Gross Motor Function Measure compared to spasticity. [23]

1.1 NEED OF THE STUDY

The spastic diplegics children with crouching have greater difficulties related to ambulation and functional activities. [10] These children have limitation in speed, timing, muscle strength or power and endurance. Children with cerebral palsy thus either remain on a wheelchair or reach a indoor walking levels. [21] The energy spend on their atypical gait patterns are believed to be very high compared to typical walkers. Also, the spatial and temporal parameters of gait including step, stride length, toe clearance during gait, cadence etc are also affected [24] and thereby these children with cerebral palsy have limitations in social participation. Physiotherapists aims at promoting the ability of ambulation or to participate in functional activities in children with cerebral palsy. [12]

There are lots of literature supports and studies on the outcomes or effects various exercises or training on the variety of symptoms. These includes NDT, Progressive exercises training, Open Kinetic Training etc. But, there are lack of literatures which compare the efficacy of functional resistance training and these symptoms based treatments for improving functional gait in children with CP. Thus, this study aims to compare the efficacy of functional resistance training over conventional symptoms oriented treatment approach for improving gait parameters in spastic crouchers aged below 14 years.

1.2 HYPOTHESIS

1.2.1 NULL HYPOTHESIS

Both approach, i.e functional resistance exercises and conventional symptoms oriented treatment approach have same effects on the gait parameters of spastic diplegics aged below 14 Years.

1.2.2EXPERIMENTAL HYPOTHESIS

There are significant difference between conventional symptoms oriented treatment approach and functional resistance training on gait parameters of spastic diplegics aged below 14 Years.

1.3 OBJECTIVES

- To study the effectiveness of conventional symptoms oriented treatment approach on gait parameters of spastic diplegics aged below 14 Years.

- To study the effectiveness of functional resistance training on gait parameters of spastic diplegics aged below 14 Years.

- To compare the effectiveness of conventional symptoms oriented treatment approach and functional resistance training on gait parameters of spastic diplegics aged below 14 Years.

Review of Literature

Chapter 2

REVIEW OF LITERATURES

Bax M, Goldstein M, Rosenbaum *et al* (2005) states cerebral palsy is a non -progressive brain disorder that covers a number of neurological conditions resulting in atypical development of movement and postural control. [25]

Himmelman K, Hagberg G, Beckung E, Hagberg B, Uvebrant P et al (2001) reported that the incidence of CP is of 1.5 – 2.5 per 1000 live births. [5]

According to the "**The International Classification of Functioning - Disability and Health of WHO**" the clinical manifestations of CP children limits them to perform their activities of daily living and confines them in playing their role in the society as an individual. [6]

Kim WH and Park E Y et al. (2010) studied causal relation between spasticity, strength, gross motor function and functional outcome in children with cerebral palsy using Manual Muscle Test, Modified Ashworth Scale, Pediatric Evaluation of Disability Inventory. The study proposed that spasticity had a significant negative indirect effect and that strength had a significant positive indirect effect on functional outcomes. [5]

Eek M N et al. (2010) studied muscle strength and gait pattern of spastic diplegics using measurement of muscle strength in eight muscle groups in the legs and three dimensional gait analysis. The result of this study stated that,

spastics diplegics were significantly affected with strength and its relationships with the overall muscle pattern. [23]

Nystrom M et al. (2008) studied the relation between muscle strength and walking ability of spastic diplegics with a hand held myometer. They concluded that there were moderate to high correlation between muscle strength and GMFM, indicating that muscle weakness affects walking ability. [21]

Gray L G. Hennie N G. Bartlett D et al (2010) discuss that GMFCS has been the primary classification system used both clinical and research settings. They observed a progressive use of GMFCS over the last decade and demonstrate excellent uptake in clinical trials. [20]

Fowler E G et al. (2010) noted significant improvements in locomotor functions, gross motor functions and strengths following resisted compound exercises (cycling). They used 600 yards walk run test, thirty second walk test, GMFM 66 and peak knee extensor and flexor isometrics are their outcome measures. [18]

Scholtes V A et al. (2008) studied customised PRE program including groups therapy for 3 times a week, for a period of 12 weeks on GMFM, functional muscle strength, mobility and sports activities. They concluded that progressive strength training can lead to increased strength and improved function in children with spastic cerebral palsy. [27]

Kerr C et al (2008) states that energy efficiency during gait was shown to correlate significantly with activity limitations. The energy efficiency of walking is not reflective of participation restriction or health status. Thus, therapies leading to improved energy efficiency may not necessarily lead to improved participation or general health. [28]

Paterson K L et al. (2008) has stated both the single and continuous over ground walking conditions to be reliable collection methods for gait data.[29]

Williams H and Pountney T et al.(2007) in their study investigated the effects of compound resistance exercise on the motor function of children cerebral palsy using GMFM and observed valuable improvements in the functional abilities in young people with cerebral palsy. [30]

Liao N F et al (2007) studied the effectiveness of a functional strengthening program on GMFM, gait parameters, strength and Physiological Cost Index for children with cerebral palsy and concluded that children with mild spastic diplegia improved their functional muscle strength and ambulation skills. [31]

Wang HY et al (2006) compared the responsiveness to motor change GMFM-88 & GMFM-66 in children with cerebral palsy and concluded that (CP overall responsiveness of GMFM-66 is superior to that of GMFM-88. [32]

Woollacott M et al (2005) studied the efficacy of reactive balance training children with cerebral palsy using movable force plate and concluded that

reactive balance training is an excellent method to develop postural reflex organization in children with spastic cerebral palsy.[33]

Law L S H et al (2005) concluded his study on 'adaptive gait pattern in obstacle clearance' on spastic diplegics stating that the motor problem in children with CP mainly reflects an implicit rather than explicit process. i.e impaired torque dynamic control. [34]

Burney H M et al. (2003) analysed the benefits of strength training for young people with cerebral palsy and concluded that the training improved flexibility, posture, strength, flexibility and walking skills along with psychological well being and improved social participation. [35]

Blundell S W et al (2003) concluded that task oriented exercise programs including strength training for children with cerebral palsy resulted in improved strength and functional performances. This training significantly benefited that children with cerebral palsy in improving their ambulatory skills to a great extend. [36]

Dodd K J et al (2002) concluded his systematic review stating the availability of evidence supporting that strength training programs can promote muscle strength in children with cerebral palsy. [37]

Russell D J et al. (2000) examined the reliability, validity, and responsiveness of GMFM-66 and concluded that GMFM-66 can be used as a

better tool to evaluate motor development for children with CP than the GMFM 88. [38]

Liano H F et al. (1997) compared relationship of standing balance and functional ambulation using used balance and walking performance tests and concluded that focus shall be put on rapid and rhythmic lateral weight shifts to improve balance skills of children with cerebral palsy. [39]

Materials and Methodology

Chapter 3

MATERIALS AND METHODOLOGY

3.1 MATERIALS

- Stop watch
- Stationeries (Measuring tape, Pencil, chalk, Paper sheets)
- Resistance Bands / Free Weights
- Balance board
- Static cycle
- Treadmill
- Foot stool
- Stair steps
- Wedge blocks & construction Rings

3.2 STUDY DESIGN

Experimental Study

Type - Comparative study

3.3 STUDY SETTING

The study was conducted among the Spastic Diplegic Cerebral Palsy Children who attended for Physiotherapy services at District Early Intervention Centre, Malappuram, Kerala.

3.4 CRITERIA FOR SAMPLE COLLECTION

3.4.1 INCLUSION CRITERIA

Age 4 -14

Both male and female children

Spastic Diplegic cerebral palsy

GMFCS level I and II

Lower limb Spasticity < 2 (as per MAS)

3.4.2 EXCLUSION CRITERIA

Any other Cerebral Palsy

GMFCS III and above

Visual impairment

Sensory impairments

Perceptual and Cognitive Dysfunction

Fixed Deformities

Regular seizers disorders

Regular Botox or related medication

3.5 POPULATION AND SAMPLING

- Population: Spastic Diplegics Cerebral Palsy children
- Sample: Spastic Diplegia Cerebral Palsy children attending Physiotherapy services
- Sampling: Convenient sampling
- Sample size: 30 Spastic Diplegic Cerebral Palsy

With convenient sampling, 30 subjects recruited were randomly allocated into two groups.

Group A - (n=15) Functional Resistance training in the form of close Kinetic Strengthening, balance training, static cycling, treadmill training, Cycling etc.

Group B - (n=15) Conventional Symptom based treatment approach – Individual or open kinetic muscle re-education program

3.6 INSTRUMENTATION

Non Invasive techniques only

3.7 TECHNIQUES OF DATA COLLECTION

The subjects who fulfilled the selection criteria were shortlisted and informed consent* was taken from parents of 30 children. They were selected using regular pediatric assessment* under the supervision of subject experts. The study was a single blinded experimental comparative study.

The subjects were randomly divided in to two groups. Group A (Functional Resistance training Group) and Group B (Symptom Based Treatment Group). Pre-Intervention data including GMFM 66 and Gait parameters of gait (stride length, step length and cadence) were collected before any treatment administration.

Later, Subjects in Group A were treated with close kinetic strength training (compound exercises) including resisted squats, sit to stand on low stool, reverse walking against resistance, stair climbing, obstacle crossing, reach outs, treadmill and community walks for 80 - 90 minutes regularly. This included preparatory warm ups, stretches and cool down exercises.

Group B children were given with open kinetic strength training exercises which included classical muscle based progressive resisted exercises (PRE). Individual weaker muscles were strengthened using weigh cuffs, free weights, free exercises like straight leg raises, bridging exercises, prone knee bending, quadriceps table exercises, static hams, glutes, quadriceps etc. The entire program lasted for 80 - 90 minutes including preparatory warm ups, stretches and cool down exercises.

Post Intervention Data were collected after 4 months of continuous therapy (strengthening program). The treatment program was continuously monitored by the researchers through clinical therapists, parents and therapy dairies.

Stride length and step length were taken by wet imprints. [40] Cadence was calculated by making the child walking for 1 minute and number of step per minute was noted. 3 trails are taken for each measurements.

The outcome measurement values were then copied to MS Excel for tabulation and then taken for statistical analysis.

3.8 TECHNIQUES OF DATA ANALYSIS

The data availed were tabulated using MS Excel. The demographic data like age and sex of the subjects in both groups were tabulated to know about the distribution of sample. Later, test for significance was done. The data were

analysed by using Statistical Package for Social Sciences, Version-20 (SPSS-20). Paired t-test was used for to know difference within the group and Independent t-test for between group comparisons.

Data Presentation & Analysis

Chapter 4

DATA PRESENTATION & ANALYSIS

Demographic Data of the subjects:

Age in Years	Group A	Group B
6 to 8	3	4
8 to 10	5	4
10 to 12	4	3
12 to 14	3	4

Table-1: Age wise distribution of subjects among groups

	Group A	Group B
Male	9	10
Female	6	5

Table 2, , Gender wise distribution of subjects among groups

The above tables describes the gender distribution of the subjects in both groups. Group-A had 9 males and 6 females where as in group B, there were 10 males and 5 females.

GROUP A	MEAN	SD	SE	T	P
GMFM	Pre	53.1	2.5	0.64	-29.5	<0.0001
	Post	64.6	2.7	0.7		
Stride Length	Pre	22.8	9.1	2.3	-6.2	<0.001
	Post	55.4	19.4	5		
Step Length	Pre	12.4	6.1	1.6	-8.5	<0.001
	Post	29.5	8.8	2.3		
Cadence	Pre	81.7	36.1	9.3	-6.5	<0.001
	Post	100.8	33.7	8.7		

Table 3: Analysis of pre and post intervention values in Group-A by Paired t-test.

The above table describes analysis done by using paired t-test for GMFM, stride length, step length and cadence of Group-A. It was done between before and after intervention The mean ± SD for GMFM before intervention is 53.1 ± 2.5 and after intervention is 64.6 ± 2.7 with p value being less than 0.001 shows that there is statistically significant improvement in gross motor function after intervention. The mean ± SD for stride length before intervention is 22.8 ± 9.1 and after intervention is 55.4 ± 19.4 with p value being less than 0.001 shows that there is statistically significant improvement in stride length after intervention. The mean ± SD for step length before intervention is 12.4 ± 6.1 and after intervention is 29.5 ± 8.8 with p value being less than 0.001 shows that there is statistically significant

improvement in step length after intervention. The mean ± SD for cadence before intervention is 81.7 ± 36.1 and after intervention is 100.8 ± 33.7 with p value being less than 0.001 shows that there is statistically significant improvement in cadence after intervention.

GROUP A		MEAN	SD	SE	T	P
GMFM	Pre	49.3	4.2	1.1	-4.41	<0.001
	Post	51.6	4.7	1.2		
Stride Length	Pre	27.3	7.2	1.9	-3	0.010
	Post	35.1	11.6	3		
Step Length	Pre	14.18	4.1	1.1	-5.1	<0.001
	Post	19.6	5.2	1.3		
Cadence	Pre	76.2	28.2	7.3	-9	<0.001
	Post	84.1	29.5	7.6		

Table 4: Analysis of pre and post intervention values in Group-B by Paired t-test.

The above table shows analysis by paired t-test for GMFM, stride length, step length and cadence in Group-B tested between before and after intervention. The mean ± SD for GMFM before intervention is 49.3 ± 4.2 and after intervention is 51.6 ± 4.7 with p value being less than 0.001 shows that there is statistically significant improvement in gross motor function after intervention. The mean ± SD for stride length before intervention is 27.3 ± 7.2 and after intervention is 35.1

± 11.61 with p value being than 0.010 shows that there is no statistically significant improvement in stride length after intervention. The mean ± SD for step length before intervention is 14.2 ± 4.1 and after intervention is 19.6 ± 5.2 with p value being less than 0.001 shows that there is statistically significant improvement in step length after intervention. The mean ± SD for cadence before intervention is 76.2. ± 28.2 and after intervention is 84.1 ± 29.5 with p value being less than 0.001 shows that there is statistically significant improvement in cadence after intervention.

	GROUP	MEAN	SD	SE	T	P
Pre	GROUP A	53.1	2.5	0.64	3.06	0.005
	GROUP B	49.3	4.2	0.68		
Post	GROUP A	64.6	2.7	1.07	9.3	0.0001
	GROUP B	51.6	4.7	1.2		

Table 5: Comparative Analysis of GMFM by independent t-test

Pre and Post intervention scores of GMFM scores were analysed between groups to study the significance difference between groups using independent t-test. The values obtained are shown in Table 5. Analysis of pre intervention values shows $p > 0.05$ proves homogeneity of groups before intervention. The analysis of post intervention values of GMFM for both groups have p value < 0.05 shows that

there is statistically significant difference between two interventions in improving gross motor function.

	STRIDE LENGTH	MEAN	SD	SE	T	P
PRE	GROUP A	22.8	9.1	2.4	-1.5	0.142
	GROUP B	27.3	7.2	5		
POST	GROUP A	55.4	19.4	1.9	3.5	0.002
	GROUP B	35.1	11.6	3		

Table 6, Comparative Analysis of Stride Length by independent t-test

Stride length values were analysed between Group – A and Group – B to find out the significance by independent t-test. The values are given in Table - 6. Analysis of baseline values shows $p > 0.05$ proves homogeneity in groups before intervention. The analyses of post intervention values of stride length for both groups have p value < 0.05 shows that there is statistically significant difference between two interventions in improving stride length.

	STEP LENGTH	MEAN	SD	SE	T	P
PRE	GROUP A	12.4	6.1	1.6	-0.97	0.341
	GROUP B	14.2	4.1	1.1		
POST	GROUP A	29.5	8.8	2.3	3.74	0.001
	GROUP B	19.6	5.2	1.3		

Table 7, Comparative Analysis of Step Length by independent t-test

Step length values were analysed between Group – A and Group – B to find out the significance by independent t-test. The values are shown in Table - 7. Analysis of baseline values shows p > 0.05 proves homogeneity of groups before intervention. The analysis of post intervention values of step length for both groups have p value < 0.05 shows that there is statistically significant difference between two interventions in improving step length.

CADENCE	MEAN	SD	SE	T	P
PRE	GROUP A	81.7	36.12	9.3	0.462	0.648
	GROUP B	100.8	28.22	7.3		
POST	GROUP A	76.2	33.1	8.7	1.45	0.159
	GROUP B	84.1	29.5	7.6		

Table 8, Comparative Analysis of Cadence by independent t-test

Cadence values were analysed between the groups to study the significance difference by independent t-test. The values are shown in Table-7. Analysis of baseline values shows p > 0.05 proves homogeneity of groups before intervention. The analysis of after intervention values of cadence for both groups have p value > 0.05 shows that there is no statistically significant difference between two interventions in improving cadence.

Results and Discussion

Chapter 5

RESULTS & DISCUSSION

The purpose of this study is to compare the effectiveness of based treatment and functional resistance training of gait in spastic diplegic cerebral palsy children aged between 6 - 14 years. 30 children, aged below 14 years of age, diagnosed with spastic diplegic Cerebral Palsy were selected. Among them, 60% were male and 40% female. The subjects were randomly divided into two groups, one group receiving Functional resistance training (Group A) and other group Symptoms Based Treatment (Group B). The functional resistance training were included with treadmill training, reverse walking, sit to stand, squatting, stair climbing, over ground walking, obstacle crossing reach out activities etc. The symptom based treatment were included with open kinetic progressive resistance training (PRE) strength training. GMFM 66, Stride length, Step Length and Cadence were considered as the outcome measures.. Each session of therapy was carried out for approximately 90 minutes regularly for 4 months.

In Group A (Functional resistance training) the obtained mean ± SD for the main outcome measure GMFM was 53.1 ± 2.5 (pre) and 64.6 ± 2.7 (post) with p value <0.001 which shows statistically significant difference after intervention. And in other outcome measures step length, stride length and cadence the obtained mean ± SD was 12.4 ± 6.1, 22.8 ± 9.1 and 81.7 ± 36.1 (pre) , 29.5 ± 8.8, 55.4 ± 19.4 and 100.8 ± 33.7 (post) respectively, with p value <0.001 which shows statistically significant improvement after intervention.

In Group B (Symptom Based Treatment) the obtained mean ± SD for the main outcome measure GMFM was 49.3 ± 4.2 (pre) and 51.6 ± 4.7 (post) with p value <0.001 which shows statistically significant difference after intervention. And in other outcome measures step length, stride length and cadence the obtained mean ± SD was 27.3 ± 7.2, 14.2 ± 4.1 and 76.2 ± 28.2 (pre) , 35.1 ± 11.6, 19.6 ± 5.2 and 84.1 ± 29.5 (post) respectively, with p value <0.001 which shows statistically significant improvement after intervention.

When both groups were compared statistically with independent t test, the main outcome measure GMFM showed statistically significant improvement with p value <0.001 in group A compared to group B. And in other outcome measures stride length and step length also showed statistically significant improvement with p value <0.001 in group A compared to group B. But cadence did not showed statistically significant difference between the groups with p value > 0.05.

In this study, the researcher has observed both males and female children are equally affected with cerebral palsy. No gender had a higher incidence of spastic cerebral palsy. Reports from World Health Organization stated that cerebral palsy can affect both genders in equal ration. [6]

All children with cerebral palsy had significantly reduced muscle power. Children with CP complain of fatigue at very low intensive activities also. These weaknesses were observed more associated with proximal muscles in crouching in contrast to the distal muscular weakness in hemiparetic. There were similar observation reported by Corry et al (1999) [41] J Rodda and H K Graham (2001). [42]

Another observation during the study was that most of the diplegic stiff knee cerebral palsy children had the tendency towards crouching in the later ages. The attitude of stiff knee have given away to crouching over a period of time, ie. 3.5 Years or later. These observations of the researcher were supported by unpublished observations by many paediatric-therapists. The researcher hypothesizes that this may be due to the failed calf muscle, weight gain of the child and alteration of the line of ground reaction force due to hip and knee flexion.

Many children with crouching were having pseudo adduction, ie. Internal rotation at the hip joint made the limb appear adducted. The medial femoral rotation, lateral tibial rotation and foot deformities are other common bony problems.

The reviews on the scope of resistance training on spastic muscles explained that the strength training programs were not appreciated in the yesteryears because it was felt this would increase spasticity and reduce flexibility**,** [11] thereby worsening the deformities and misalignments. However, these days there are a lot of research conclusions which have proven resistance training can produce changes in the muscle strength of spastic CP at the same rate as persons without brain lesion without decreasing the flexibility**.** [43 - 54] Also, it is believed that these training programs administered as compound training sessions can favour worthy progress in the functional motor skills including gait.

In functional resistance training, unlike simple progressive resistance training of individual muscles, the task encouraged the client and the child performed the acts (customised exercises) repeatedly though the intensity were high. [55]

Mc Fadyen et al found visual inputs are the primary source of modification of walking pattern. For example, that normal subjects while crossing an obstacle, flexes the hip, knee and ankle. These modifications of walking patterns are explained in terms of anticipatory control of dynamic balance. Clear view of obstacle is largely influence dynamic experiences. [56]

Blundell SW et al found that functional exercises have the potential to train motor control including co ordination, balance, strength, endurance and general conditioning. And repetition of specific tasks in the right environmental factors refine the efficient movement patterns required for optimal functions. This study agrees with Buchner's work which implies that task dependent level of strength is attained, other factors such as skill training become more important to improve performance.[36]

Spasticity, assessed using Modified Ashworth Scale (MAS), remained more or less unchanged with the intervention in all the three categories of CP.

This observation correlated with the reports of the studies performed by Scholter V A et al, Andersson C et al. Patikas D et al, Lee JH et al, Mac Phail HE et al, Dodd KJ et al, Taylor NF et al, Verschuren O et al, Dodd KJ et al, which concluded that functional resistance training did not increase spasticity. [44 - 52]

Summary & Conclusion

Chapter 6
SUMMARY & CONCLUSION

Functional Resistance Training is slowing gaining recognition among the Physiotherapist dealing with Cerebral Palsy. However the practical application of this compound strength training has not studied yet in developing the ambulatory skills of Spastic Diplegics. **This** study studied the effectiveness of 'functional resistance training' and compare it with conventional 'symptom based treatment' approach in improving gait parameters of spastic diplegics aged below 14 years. Single blinded experimental, comparative study done at District Early Intervention Centre, Malappuram. 30 numbers of Conveniently chosen Spastic Diplegics aged between 6 - 14 years were randomly divided into 2 groups. Group A & B (Experimental and Conventional respectively) were intervened for 90 Minutes of therapy regularly for 4 months. GMFM 66, Stride length, Step length and Cadence were considered as the outcome measures. Pre and Post intervention values were tabulated and treated statistically using 't tests'.

The result of this study shows that Functional Resistance Training is more effective than Symptoms Based Treatment in improving ambulation activities limitation in Spastic Diplegic children aged below 14 Years. This gives evidence for treatment of children with CP with active participation and short term goal oriented approach, which will give more motivation to the child for treatment sessions and also help to gain more motor controls. Thus the current study shows the importance for the physical therapy to focus more on functional resistance training of children with CP than conventional symptom based treatment approach.

Limitations and Recommendations

Chapter 6

LIMITATIONS & RECOMMENTATIONS

Recommendations for future studies:

- An RCT using the same variables with a larger sample
- Involve larger samples from all categories of cerebral palsy
- Further studies can be conducted with higher age groups
- The long term effects can be evaluated.

Study Limitations

- The sample size used for the study was small.
- Long term effects of treatment were not assessed.
- Parental involvement was not established.

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Chapter 8
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Annexure

ANNEXURE 1

CONSENT FORM

I …….. residing at ……..…… …… …… ……..do here by give my consent to allow my ward (child) to be taken as a subject in the proposed study conducted by Ms. LINSHINA T of Cherraan's College of Physiotherapy, Coimbatore. I have decided to volunteer my child for study on my own will and was not compelled by any individual or group of people and my consent is not for any monetary benefits.

The treatment procedure that will be executed on my child is fully explained to me by……in the language best known to me and I am aware that my child being subjected to this study and I'll have to give more time for assessments and treatment; and these assessments do not interfere with benefits.

I have the right to refuse my consent / or withdraw my child from it any time during the course of the study without adversely affecting my treatment. By signing this consent from I understand that I agree to all the terms and conditions of investigator and I shall not make her liable for an ill health / lack of improvement.

The matter in this consent form was read by me / read to me by an interpreter and I fully understood the subject matter.

DATE:

PLACE

SIGNATURE OF PARENT SIGNATURE OF INVESTIGATOR

ANNEXURE II

Paediatric Assessment Form

- PATIENT DATA:

  Name:

  Age/sex:

  DOB:

  DOE:

  School/standard:

  Hand dominance:

  Mother Tongue:

- REASON FOR REFERRAL:
- PRESENTING COMPLAIN**S**

- SUBJECTIVE EXAMINATION
- HISTORY
  1) Prenatal history
  2) Perinatal history
  3) Postnatal history
  4) Maternal history
  5) Family history

- OBJECTIVE EXAMINATION

▪ ON OBSERVATION

✓ Behaviour of child
✓ Communication of child
✓ Attention
✓ Position of child
✓ Postural control and alignment
✓ Use of limbs and hands
✓ Sensory aspects
✓ Form of locomotion
✓ Deformities

- ON EXAMINATION

✓ Sensory assessment

✓ Motor assessment

- Growth parameters
- Joint range of motion (active and passive)
- Neonatal Reflexes
- Muscle tone
- Muscle strength
- Reflexes
- Limb length discrepancy
- Contractures
- Deformities

✓ GROSS MOTOR FUNCTION CLASSIFICATION SYSTEM ASSESSMENT

Level I – Walks without limitations

Level II – Walks with limitations

Level III – Walks using a hand held mobility device

Level VI – Self mobility with limitations: may use powered mobility

Level V – Transported in a manual wheelchair

✓ Gait assessment (temporal and spatial parameters)

✓ Transfer activities

✓ Balance

ANNEXURE III

GROSS MOTOR FUNCTION MEASURE (GMFM)
SCORE SHEET (GMFM-88 and GMFM-66 scoring)

Version 1.0

Child's Name: _____ ID #: _____

Assessment date: _____ year / month /day

Date of birth: _____ year / month /day

Chronological age: _____ years/months

GMFCS Level [1]

☐ I ☐ II ☐ III ☐ IV ☐ V

Testing Conditions (eg, room, clothing, time, others present)

Evaluator's Name: _____

_____

_____

_____

The GMFM is a standardized observational instrument designed and validated to measure change in gross motor function over time in children with cerebral palsy. The scoring key is meant to be a general guideline. However, most of the items have specific descriptors for each score. It is imperative that the guidelines contained in the manual be used for scoring each item.

SCORING KEY
0 = does not initiate
1 = initiates
2 = partially completes
3 = completes
NT = Not tested [used for the GMAE scoring*]

It is now important to differentiate a true score of "0" (child does not initiate) from an item which is Not Tested (NT) if you are interested in using the GMFM-66 Ability Estimator Software.

*The GMFM-66 Gross Motor Ability Estimator (GMAE) software is available with the GMFM manual (2002). The advantage of the software is the conversion of the ordinal scale into an interval scale. This will allow for a more accurate estimate of the child's ability and provide a measure that is equally responsive to change across the spectrum of ability levels. Items that are used in the calculation of the GMFM-66 score are shaded and identified with an asterisk (*). The GMFM-66 is only valid for use with children who have cerebral palsy.

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[1] GMFCS level is a rating of severity of motor function. Definitions are found in Appendix I of the GMFM manual (2002).

Check (√) the appropriate score: If an item is not tested (NT), circle the item number in the right column

Item	A: LYING & ROLLING	SCORE				NT
1.	SUP, HEAD IN MIDLINE: TURNS HEAD WITH EXTREMITIES SYMMETRICAL	0 ☐	1 ☐	2 ☐	3 ☐	1.
* 2.	SUP: BRINGS HANDS TO MIDLINE, FINGERS ONE WITH THE OTHER	0 ☐	1 ☐	2 ☐	3 ☐	2.
3.	SUP: LIFTS HEAD 45°	0 ☐	1 ☐	2 ☐	3 ☐	3.
4.	SUP: FLEXES R HIP AND KNEE THROUGH FULL RANGE	0 ☐	1 ☐	2 ☐	3 ☐	4.
5.	SUP: FLEXES L HIP AND KNEE THROUGH FULL RANGE	0 ☐	1 ☐	2 ☐	3 ☐	5.
* 6.	SUP: REACHES OUT WITH R ARM, HAND CROSSES MIDLINE TOWARD TOY	0 ☐	1 ☐	2 ☐	3 ☐	6.
* 7.	SUP: REACHES OUT WITH L ARM, HAND CROSSES MIDLINE TOWARD TOY	0 ☐	1 ☐	2 ☐	3 ☐	7.
8.	SUP: ROLLS TO PR OVER R SIDE	0 ☐	1 ☐	2 ☐	3 ☐	8.
9.	SUP: ROLLS TO PR OVER L SIDE	0 ☐	1 ☐	2 ☐	3 ☐	9.
* 10.	PR: LIFTS HEAD UPRIGHT	0 ☐	1 ☐	2 ☐	3 ☐	10.
11.	PR ON FOREARMS: LIFTS HEAD UPRIGHT, ELBOWS EXT., CHEST RAISED	0 ☐	1 ☐	2 ☐	3 ☐	11.
12.	PR ON FOREARMS: WEIGHT ON R FOREARM, FULLY EXTENDS OPPOSITE ARM FORWARD	0 ☐	1 ☐	2 ☐	3 ☐	12.
13.	PR ON FOREARMS: WEIGHT ON L FOREARM, FULLY EXTENDS OPPOSITE ARM FORWARD	0 ☐	1 ☐	2 ☐	3 ☐	13.
14.	PR: ROLLS TO SUP OVER R SIDE	0 ☐	1 ☐	2 ☐	3 ☐	14.
15.	PR: ROLLS TO SUP OVER L SIDE	0 ☐	1 ☐	2 ☐	3 ☐	15.
16.	PR: PIVOTS TO R 90° USING EXTREMITIES	0 ☐	1 ☐	2 ☐	3 ☐	16.
17.	PR: PIVOTS TO L 90° USING EXTREMITIES	0 ☐	1 ☐	2 ☐	3 ☐	17.

TOTAL DIMENSION A ☐

Item	B: SITTING	SCORE				NT
* 18.	SUP, HANDS GRASPED BY EXAMINER: PULLS SELF TO SITTING WITH HEAD CONTROL	0 ☐	1 ☐	2 ☐	3 ☐	18.
19.	SUP: ROLLS TO R SIDE, ATTAINS SITTING	0 ☐	1 ☐	2 ☐	3 ☐	19.
20.	SUP: ROLLS TO L SIDE, ATTAINS SITTING	0 ☐	1 ☐	2 ☐	3 ☐	20.
* 21.	SIT ON MAT, SUPPORTED AT THORAX BY THERAPIST: LIFTS HEAD UPRIGHT, MAINTAINS 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	21.
* 22.	SIT ON MAT, SUPPORTED AT THORAX BY THERAPIST: LIFTS HEAD MIDLINE, MAINTAINS 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	22.
* 23.	SIT ON MAT, ARM(S) PROPPING: MAINTAINS, 5 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	23.
* 24.	SIT ON MAT: MAINTAINS, ARMS FREE, 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	24.
* 25.	SIT ON MAT WITH SMALL TOY IN FRONT: LEANS FORWARD, TOUCHES TOY, RE-ERECTS WITHOUT ARM PROPPING	0 ☐	1 ☐	2 ☐	3 ☐	25.
* 26.	SIT ON MAT: TOUCHES TOY PLACED 45° BEHIND CHILD'S R SIDE, RETURNS TO START	0 ☐	1 ☐	2 ☐	3 ☐	26.
* 27.	SIT ON MAT: TOUCHES TOY PLACED 45° BEHIND CHILD'S L SIDE, RETURNS TO START	0 ☐	1 ☐	2 ☐	3 ☐	27.
28.	R SIDE SIT: MAINTAINS, ARMS FREE, 5 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	28.
29.	L SIDE SIT: MAINTAINS, ARMS FREE, 5 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	29.
* 30.	SIT ON MAT: LOWERS TO PR WITH CONTROL	0 ☐	1 ☐	2 ☐	3 ☐	30.
* 31.	SIT ON MAT WITH FEET IN FRONT: ATTAINS 4 POINT OVER R SIDE	0 ☐	1 ☐	2 ☐	3 ☐	31.
* 32.	SIT ON MAT WITH FEET IN FRONT: ATTAINS 4 POINT OVER L SIDE	0 ☐	1 ☐	2 ☐	3 ☐	32.
33.	SIT ON MAT: PIVOTS 90°, WITHOUT ARMS ASSISTING	0 ☐	1 ☐	2 ☐	3 ☐	33.
* 34.	SIT ON BENCH: MAINTAINS, ARMS AND FEET FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	34.
* 35.	STD: ATTAINS SIT ON SMALL BENCH	0 ☐	1 ☐	2 ☐	3 ☐	35.
* 36.	ON THE FLOOR: ATTAINS SIT ON SMALL BENCH	0 ☐	1 ☐	2 ☐	3 ☐	36.
* 37.	ON THE FLOOR: ATTAINS SIT ON LARGE BENCH	0 ☐	1 ☐	2 ☐	3 ☐	37.

TOTAL DIMENSION B ☐

Item		E: WALKING, RUNNING & JUMPING	SCORE				NT
*	65.	STD, 2 HANDS ON LARGE BENCH: CRUISES 5 STEPS TO R	0 ☐	1 ☐	2 ☐	3 ☐	65.
*	66.	STD, 2 HANDS ON LARGE BENCH: CRUISES 5 STEPS TO L	0 ☐	1 ☐	2 ☐	3 ☐	66.
*	67.	STD, 2 HANDS HELD: WALKS FORWARD 10 STEPS	0 ☐	1 ☐	2 ☐	3 ☐	67.
*	68.	STD, 1 HAND HELD: WALKS FORWARD 10 STEPS	0 ☐	1 ☐	2 ☐	3 ☐	68.
*	69.	STD: WALKS FORWARD 10 STEPS	0 ☐	1 ☐	2 ☐	3 ☐	69.
*	70.	STD: WALKS FORWARD 10 STEPS, STOPS, TURNS 180°, RETURNS	0 ☐	1 ☐	2 ☐	3 ☐	70.
*	71.	STD: WALKS BACKWARD 10 STEPS	0 ☐	1 ☐	2 ☐	3 ☐	71.
*	72.	STD: WALKS FORWARD 10 STEPS, CARRYING A LARGE OBJECT WITH 2 HANDS	0 ☐	1 ☐	2 ☐	3 ☐	72.
*	73.	STD: WALKS FORWARD 10 CONSECUTIVE STEPS BETWEEN PARALLEL LINES 20cm (8") APART	0 ☐	1 ☐	2 ☐	3 ☐	73.
*	74.	STD: WALKS FORWARD 10 CONSECUTIVE STEPS ON A STRAIGHT LINE 2cm (3/4") WIDE	0 ☐	1 ☐	2 ☐	3 ☐	74.
*	75.	STD: STEPS OVER STICK AT KNEE LEVEL, R FOOT LEADING	0 ☐	1 ☐	2 ☐	3 ☐	75.
*	76.	STD: STEPS OVER STICK AT KNEE LEVEL, L FOOT LEADING	0 ☐	1 ☐	2 ☐	3 ☐	76.
*	77.	STD: RUNS 4.5m (15'), STOPS & RETURNS	0 ☐	1 ☐	2 ☐	3 ☐	77.
*	78.	STD: KICKS BALL WITH R FOOT	0 ☐	1 ☐	2 ☐	3 ☐	78.
*	79.	STD: KICKS BALL WITH L FOOT	0 ☐	1 ☐	2 ☐	3 ☐	79.
*	80.	STD: JUMPS 30cm (12") HIGH, BOTH FEET SIMULTANEOUSLY	0 ☐	1 ☐	2 ☐	3 ☐	80.
*	81.	STD: JUMPS FORWARD 30 cm (12"), BOTH FEET SIMULTANEOUSLY	0 ☐	1 ☐	2 ☐	3 ☐	81.
*	82.	STD ON R FOOT: HOPS ON R FOOT 10 TIMES WITHIN A 60cm (24") CIRCLE	0 ☐	1 ☐	2 ☐	3 ☐	82.
*	83.	STD ON L FOOT: HOPS ON L FOOT 10 TIMES WITHIN A 60cm (24") CIRCLE	0 ☐	1 ☐	2 ☐	3 ☐	83.
*	84.	STD, HOLDING 1 RAIL: WALKS UP 4 STEPS, HOLDING 1 RAIL, ALTERNATING FEET	0 ☐	1 ☐	2 ☐	3 ☐	84.
*	85.	STD, HOLDING 1 RAIL: WALKS DOWN 4 STEPS, HOLDING 1 RAIL, ALTERNATING FEET	0 ☐	1 ☐	2 ☐	3 ☐	85.
*	86.	STD: WALKS UP 4 STEPS, ALTERNATING FEET	0 ☐	1 ☐	2 ☐	3 ☐	86.
*	87.	STD: WALKS DOWN 4 STEPS, ALTERNATING FEET	0 ☐	1 ☐	2 ☐	3 ☐	87.
*	88.	STD ON 15cm (6") STEP: JUMPS OFF, BOTH FEET SIMULTANEOUSLY	0 ☐	1 ☐	2 ☐	3 ☐	88.

TOTAL DIMENSION E ☐

Was this assessment indicative of this child's "regular" performance? YES ☐ NO ☐

COMMENTS:

Item	C: CRAWLING & KNEELING	SCORE				NT
38.	PR: CREEPS FORWARD 1.8m (6')	0 ☐	1 ☐	2 ☐	3 ☐	38.
* 39.	4 POINT: MAINTAINS, WEIGHT ON HANDS AND KNEES, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	39.
* 40.	4 POINT: ATTAINS SIT ARMS FREE	0 ☐	1 ☐	2 ☐	3 ☐	40.
* 41.	PR: ATTAINS 4 POINT, WEIGHT ON HANDS AND KNEES	0 ☐	1 ☐	2 ☐	3 ☐	41.
* 42.	4 POINT: REACHES FORWARD WITH R ARM, HAND ABOVE SHOULDER LEVEL	0 ☐	1 ☐	2 ☐	3 ☐	42.
* 43.	4 POINT: REACHES FORWARD WITH L ARM, HAND ABOVE SHOULDER LEVEL	0 ☐	1 ☐	2 ☐	3 ☐	43.
* 44.	4 POINT: CRAWLS OR HITCHES FORWARD 1.8m (6')	0 ☐	1 ☐	2 ☐	3 ☐	44.
* 45.	4 POINT: CRAWLS RECIPROCALLY FORWARD 1.8m (6')	0 ☐	1 ☐	2 ☐	3 ☐	45.
* 46.	4 POINT: CRAWLS UP 4 STEPS ON HANDS AND KNEES/FEET	0 ☐	1 ☐	2 ☐	3 ☐	46.
47.	4 POINT: CRAWLS BACKWARDS DOWN 4 STEPS ON HANDS AND KNEES/FEET	0 ☐	1 ☐	2 ☐	3 ☐	47.
* 48.	SIT ON MAT: ATTAINS HIGH KN USING ARMS, MAINTAINS, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	48.
49.	HIGH KN: ATTAINS HALF KN ON R KNEE USING ARMS, MAINTAINS, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	49.
50.	HIGH KN: ATTAINS HALF KN ON L KNEE USING ARMS, MAINTAINS, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	50.
* 51.	HIGH KN: KN WALKS FORWARD 10 STEPS, ARMS FREE	0 ☐	1 ☐	2 ☐	3 ☐	51.

TOTAL DIMENSION C ☐

Item	D: STANDING	SCORE				NT
* 52.	ON THE FLOOR: PULLS TO STD AT LARGE BENCH	0 ☐	1 ☐	2 ☐	3 ☐	52.
* 53.	STD: MAINTAINS, ARMS FREE, 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	53.
* 54.	STD: HOLDING ON TO LARGE BENCH WITH ONE HAND, LIFTS R FOOT, 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	54.
* 55.	STD: HOLDING ON TO LARGE BENCH WITH ONE HAND, LIFTS L FOOT, 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	55.
* 56.	STD: MAINTAINS, ARMS FREE, 20 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	56.
* 57.	STD: LIFTS L FOOT, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	57.
* 58.	STD: LIFTS R FOOT, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	58.
* 59.	SIT ON SMALL BENCH: ATTAINS STD WITHOUT USING ARMS	0 ☐	1 ☐	2 ☐	3 ☐	59.
* 50.	HIGH KN: ATTAINS STD THROUGH HALF KN ON R KNEE, WITHOUT USING ARMS	0 ☐	1 ☐	2 ☐	3 ☐	60.
* 51.	HIGH KN: ATTAINS STD THROUGH HALF KN ON L KNEE, WITHOUT USING ARMS	0 ☐	1 ☐	2 ☐	3 ☐	61.
* 52.	STD: LOWERS TO SIT ON FLOOR WITH CONTROL, ARMS FREE	0 ☐	1 ☐	2 ☐	3 ☐	62.
* 53.	STD: ATTAINS SQUAT, ARMS FREE	0 ☐	1 ☐	2 ☐	3 ☐	63.
* 54.	STD: PICKS UP OBJECT FROM FLOOR, ARMS FREE, RETURNS TO STAND	0 ☐	1 ☐	2 ☐	3 ☐	64.

TOTAL DIMENSION D ☐

GMFM RAW SUMMARY SCORE

DIMENSION	CALCULATION OF DIMENSION % SCORES	GOAL AREA (indicated with a "✓" check)
A. Lying & Rolling	$\frac{\text{Total Dimension A}}{51} = \frac{\quad}{51} \times 100 = \quad\%$	A. ☐
B. Sitting	$\frac{\text{Total Dimension B}}{60} = \frac{\quad}{60} \times 100 = \quad\%$	B. ☐
C. Crawling & Kneeling	$\frac{\text{Total Dimension C}}{42} = \frac{\quad}{42} \times 100 = \quad\%$	C. ☐
D. Standing	$\frac{\text{Total Dimension D}}{39} = \frac{\quad}{39} \times 100 = \quad\%$	D. ☐
E. Walking, Running & Jumping	$\frac{\text{Total Dimension E}}{72} = \frac{\quad}{72} \times 100 = \quad\%$	E. ☐

TOTAL SCORE = $\frac{\%A + \%B + \%C + \%D + \%E}{\text{Total \# of Dimensions}}$

$= \frac{\quad + \quad + \quad + \quad + \quad}{5} = \frac{\quad}{5} = \quad\%$

GOAL TOTAL SCORE = $\frac{\text{Sum of \% scores for each dimension identified as a goal area}}{\text{\# of Goal areas}}$

$= \frac{\quad}{\quad} = \quad\%$

GMFM-66 Gross Motor Ability Estimator Score [1]

GMFM-66 Score = _____ _____ to _____ 95% Confidence Intervals

previous GMFM-66 Score = _____ _____ to _____ 95% Confidence Intervals

change in GMFM-66 = _____

[1] from the Gross Motor Ability Estimator (GMAE) Software

ANNEXURE V

MASTER CHART

Functional Resistance Training								
Age	**Sex**	**GMFM**		**Stride length**		**Step length**		**Cadence**
		Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Post**
12	F	56.5	66.04	11.5	47	10	23	116
14	M	53.04	63.24	24	81	16	34	31
14	M	54.5	66.08	18.9	99	11.4	55	130
6	M	55.52	64.9	16.9	58	7.9	25	128
11	M	52.46	66.3	31.4	61	13.6	29	115
13	M	53.1	65.6	33.5	65	22.4	35	98
12	F	54.04	66	38.5	42	22.8	34	116
7	F	52.7	65	23.4	72	11.9	32	135
8	M	52.48	61.5	25.6	55	13.4	24	94
9	F	45.34	56.42	18	32	7.5	24	54
7	M	53.24	64	10	26	3.4	18	64
13	M	52.64	66.65	16.9	58	7.9	25	128
8	F	52.6	65	38.6	43	22	35	118
11	F	55.4	66.8	18	34	7.5	25	55
8	M	53.01	65.06	16.5	58	7.6	24	130

Symptom Based Treatment								
Age	**Sex**	**GMFM**		**Stride length**		**Step length**		**Cadence**
		Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Post**
13	M	49.38	50	28.4	31	11.5	13	74
10	M	53.9	63	28.5	70	11.8	31	140
8	M	53.1	54.2	36	42	14	16.5	120
11	M	47.05	502	12.8	30	7.8	15	42
9	M	51.46	53.5	29.5	33	12	18.5	74
14	M	48.8	51.2	38	43	20	24	90
9	F	47.44	49.3	32	38.5	19	24	92
14	M	47.18	48.5	26	28.5	16.8	20	102
13	M	39.18	42.7	32.2	36	9.6	12.5	39
12	M	58.08	59	26.8	28	14.2	18	72
8	F	46.8	48.6	28	34.7	11.8	18	121
7	F	47.8	49	24	28.4	18.3	25	81
10	M	50.4	52	22.5	28	19	22.5	89
9	F	49.3	51.2	12.8	24	8.9	18	42
8	F	49.2	51	32	38.5	18	22.3	83